ASK-FORCE:
Do GM crops fail to produce more yield?

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Contents

1. The Issue:

The short summary of the press release of the Union of Concerned Scientists (UCS):

"Failure to Yield is the first report to closely evaluate the overall effect genetic engineering has had on crop yields in relation to other agricultural technologies. It reviewed two dozen academic studies of corn and soybeans, the two primary genetically engineered food and feed crops grown in the United States. Based on those studies, the UCS report concluded that genetically engineering herbicide-tolerant soybeans and herbicide-tolerant corn has not increased yields. Insect-resistant corn, meanwhile, has improved yields only marginally. ***The increase in yields for both crops over the last 13 years, the report found, was largely due to traditional breeding or improvements in agricultural practices."*** *(Gurian-Sherman, 2009)*

Gurian-Sherman, D. (2009)
Failure to Yield, Evaluating the Performance of Genetically Engineered Crops, Union ot Concerned Scientists pp (Report)
www.ucsusa.org AND http://www.botanischergarten.ch/GM-General/Gurian-Sherman-failure-to-yield-2009.pdf AND
Press conference: http://www.ucsusa.org/food_and_agriculture/science_and_impacts/science/failure-to-yield.html

2. Summary

1. The report deals only with two major crops: Maize and soybean, there is no justification for the sweeping conclusions on all GM crops. Other crops like cotton and oilseed rape show a different, more positive picture, it is misleading to restrict the review to two crops and then conclude for all GM crops.
2. GM crops have – at least in the beginning – not been developed to increase yield per se (the second generation of GM soybean will do this. The first GM crop generation has been conceived to efficiently reduce yield losses to weeds and insects - and thus enhance the economic situation of the farmers, *and these promises have been fulfilled properly and with evident success.* UCS misleads the reader by not distinguishing those two views of yield.
3. GM crops have also efficiently reduced herbicide use (or made it possible to shift to environmentally more benign ones) and also they have helped to reduce pesticides. It is misleading by UCS not to mention those facts.
4. GM crops have a proven positive influence on the ecological footprint of intensive high production agriculture (no tillage, better life for non-target insects etc.). It is misleading by the UCS report to camouflage those positive effects under "agricultural practices".

3. In a response to the UCS report, Prof. Wayne Parrott, an experienced agricultural specialist, summarizes his critique:

"The report by the Union of Concerned Scientists rightly differentiates between intrinsic yield (what the crop could produce) and operational yield (what the crop actually produces). The premise of the report is that GM crops are a bad means to achieve global agricultural sustainability simply because they have not affected intrinsic yield. Surprisingly, while the report mentions 'wealth of data on yield under real-world conditions' it fails to use these data. The report focuses on corn and soybean, omitting the extensive data available from cotton and canola. Finally, the report focuses on the US, omitting the results from the rest of

world. Collectively, these omissions in the UCS report serve to distort the actual situation."

Parrott, W. (2009)
Electronic Source: An analysis of to Yield by Doug Gurian-Sherman, Union of Concerned Scientists (ed. W. Parrott), Parrottlab published by: Wayne Parrott http://mulch.cropsoil.uga.edu/~parrottlab/GMOResources.htm (Parrott, 2009)

Wayne Parrott is also cited in (Sheridan, 2009) with the following statement:
"A crop doesn't have to have a higher yield to justify its existence, profitability is farmers' primary concern, and factors such as reduced input requirements, easier crop management and improved performance all feed into farmers' decision-making processes."

4. Positive development of operational yield based on hard data Brookes and Barfoot, ISAAA report: The real impacts 1996-2006 based on sound statistics (Brookes & Barfoot, 2008):

Brookes, G. & Barfoot, P. (2008)
Biotech crops: the real impacts 1996-2006 - yields, summary and full report, PG Economics Ltd. pp 4 and 13 Wessex Barn Frampton Dorchester Dorset DT2 9NB UK (Report)
http://www.pgeconomics.co.uk/pdf/GM_Crop_yield_summary.pdf AND full report:
http://www.botanischergarten.ch/Yield/Brookes-Yield-GM-crops-2008.pdf

These authors also respond harshly and do not hesitate to rebut the UCS report in the main arguments (Brookes & Barfoot, 2009)

Brookes, G. & Barfoot, P. (2009)
Union of Concerned Scientists report on GM crop performance is misleading, PG Economics Ltd. Briefing note 17. April 2009 pp 6 Wessex Barn Frampton Dorchester Dorset DT2 9NB UK (Report)
http://www.pgeconomics.co.uk/pdf/UCSresponseapr2009.pdf

The full citation of the main arguments:

"PG Economics concludes that the UCS report title does not reflect the report findings. Fundamentally, the UCS report confirms that GM crop technology has improved crop yields and productivity in the US.

PG Economics has, below, identified a number of deficiencies in the UCS report and presented a summary of the key real impacts of GM technology. For those reviewing the UCS report, it:

"Misleads by examining issues from a narrow geographical perspective: Given GM crops have been grown commercially worldwide on a large scale since 1996, any appropriate evaluation of GM trait performance should be undertaken from a global perspective, rather than the US-only perspective adopted by the UCS. It is in developing countries where GM technology has delivered the highest positive impacts on operational yield (eg, corn in the Philippines, cotton in India) and facilitated the wider use of second cropping in a season (eg, soybeans following wheat in Argentina)

Misleads by examining issues from a narrow crop perspective. The UCS report focuses only on soybeans and corn, yet ignores the two other crops in which GM traits are widely used; cotton and canola. GM trait use in these crops has resulted in higher *operational yields for most users, increased production and improved standards of living for those farmers using the technology (including US farmers). For example, the average operational yield impact of GM insect resistant (GM IR) cotton technology*

(1996-2006) has been +11.1% across all global users• Is inconsistent: the UCS document claims in the executive summary that 'GE (genetic engineering) has done little to increase overall yields. The headline to the release also says 'failure to yield', yet the detailed content of the report shows the opposite and subsequently acknowledges that GM ***insect resistant corn has increased (operational) yields*** *in the US. The UCS report also states that 'now that transgenic crops have been grown in the US for more than a decade, there is a wealth of data on yield under real world conditions'. This gives the reader the impression that the paper is drawing on such research to come to its conclusions. Yet the vast majority of references cited in the report are of crop trials, not studies of real world experiences of commercial farmers using GM technology*

Makes inappropriate use of data. The UCS discusses the importance of increasing food production to feed a growing world population and especially the importance of improving agricultural productivity in developing countries. However, the vast majority of the data and studies drawn on do not examine agricultural productivity issues and the use of GM technology in developing countries but are almost all drawn from the US. The UCS also claims that public resources should be re-directed from GM technology research to low input/organic research. However, no data on the relative expenditures of public funds on each of these categories of research and no analysis of any benefits of such a change are presented."

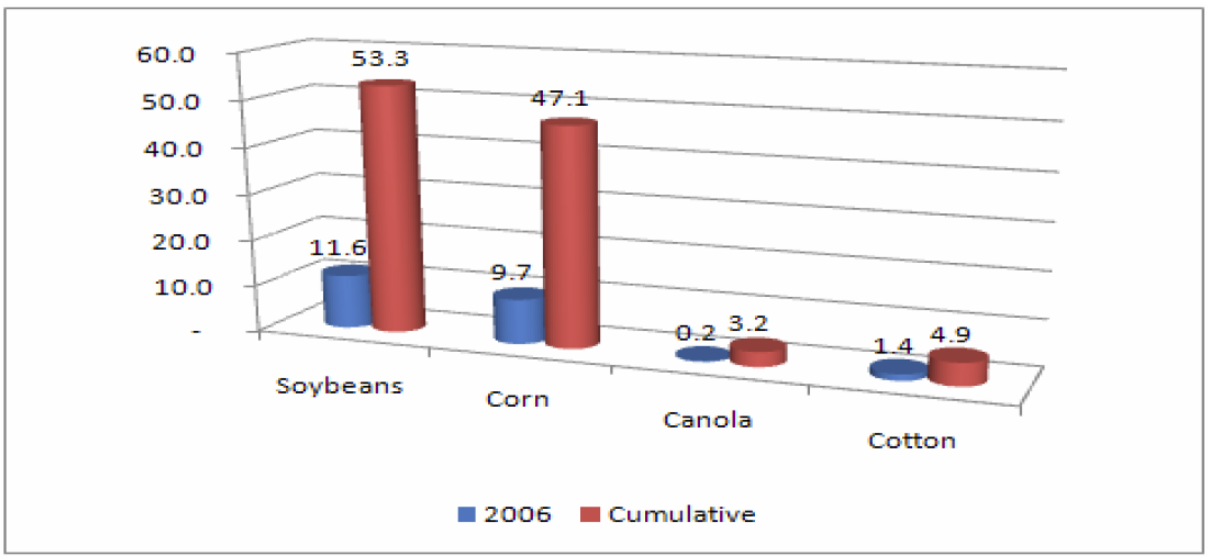

Fig. 1 Additional crop production arising from positive yield effects of biotech traits 1996-2006 (million tonnes) From (Brookes & Barfoot, 2009)

5. The classic report of 10 years of positive experience from Argentina

10 years of positive experience in Argentina as one of the examples, the data speak for themselves

(Trigo & Cap, 2006)
Ten Years of Genetically Modified Crops in Argentine Agriculture ArgenBio pp 52 Buenos Aires (Report)
http://www.botanischergarten.ch/Argentina/Trigo-10years-Argentina-2007.pdf

From the remarkably balanced conclusions:

"All of these aspects, when taken together, highlight the fact that the first decade of GM crops in argentine agriculture has been a period of large benefits, not only for the agricultural sector, but for the economy as a whole. By now it has become clear that this process has not been one free of both costs and uncertainties, issues that remain open and should be addressed and widely debated from now on. On the other hand, it would have been surprising if a transformation process of the magnitude of the one above described did not have consequences of this nature. The tremendous expansion of the soybean crop has lead to a strong repositioning of agriculture within both the economy and the foreign trade of the country, which has raised concerns about the possible negative impacts of the "soyafication" process, on the one hand, due to the excessive dependence of exports on one single commodity and, on the other, due to its implications associated with the future fertility of the country's soils and the potential detrimental effects of the crop expansion on fragile ecosystems. These concerns, as well as others that have not been addressed in the document, like, for instance, the future evolution of the international context for this type of technologies, are totally legitimate, but they should not be considered as a demerit of the clearly positive balance of the first decade of GM crops in Argentina. Nevertheless, they do emphasize the need for a debate that should take place, on ways to, both, optimize the potential of new innovations in this field, which seems to be growing on a daily basis, and limit the potential negative effects that they might cause. It is worth noting that a realistic look at the new technologies that might be forthcoming, leads to the conclusion that it is very unlikely that one like the case of herbicide-tolerant soybeans will be available in the near future. " (Trigo & Cap, 2006).

6. Millions of farmers cannot be wrong as shown by the steady increase of the cultivation acreage worldwide

Since the beginning of the cultivation of GM crops we have a steady increase of the acreage. And since still the farmers are the main decisionmakers on what they want to produce, this development cannot be diminished to false arguments of seed companies pressuring the farmers. See slide collection below.

(James, 2009)
Global Status of Commercialized Biotech/GM Crops: 2008, Brief 39, Executive Summary, Vol. Brief 39, pp. 20. ISAAA
http://www.botanischergarten.ch/ISAAA/ISAAA-Briefs-39-Executive-Summary.pdf AND
http://www.botanischergarten.ch/ISAAA/Brief39Slides-2008.pdf

As a result of the consistent and substantial economic, environmental and welfare benefits offered by biotech crops, millions of small and resource-poor farmers around the world continued to plant more hectares of biotech crops in 2008, the thirteenth year of commercialization. Progress was made on several important fronts in 2008 with: significant increases in hectarage of biotech crops; increases in both the number of countries and farmers planting biotech crops globally; substantial progress in Africa, where the challenges are greatest; increased adoption of stacked traits and the introduction of a new biotech crop. These are very important developments given that biotech crops can contribute to some of the major challenges facing global society, including: food security, high price of food, sustainability, alleviation of poverty and hunger, and help mitigate some of the challenges associated with climate change. Number of countries planting biotech crops soars to 25 – a historical milestone – a new wave of adoption of biotech crops is contributing to a broad-based and continuing hectarage growth of biotech crops globally. (James, 2009).

7. IFPRI, a CGIAR – affiliated international organization, just published an positive balance on the economic side of GM crops:

Smale, M., Zambrano, P., Gruere, G., Falck-Zepeda, J., Matuschka, I., Horna, D., Nagarjan, L., Yerramareddy, I., & Jones, H. (2009)
Measuring the economic impacts of transgenic crops in developing agriculture during the first decade : approaches, findings, and future directions. In II. Series: Food policy review ; 10. 125 pp. (eds. IFPRI). IFPRI, Washington. ISBN 978-0-89629-511
http://www.ifpri.org/pubs/fpreview/pv10.pdf
AND http://www.botanischergarten.ch/Yield/Smale-Measuring-Crops-IFPRI-2009.pdf

In the conclusions, although with caveats, they paint a positive picture on the economic importance of GM crops in the developing countries:

"Literature about the economic impact of transgenic crops on farmers is the most extensive among the four topic areas examined; it is also especially informative because almost all of it is ex post. In contrast to ex ante analysis of potential impacts, ex post research documents actual patterns of adoption and impacts. During the first decade of their use by smallholder farmers in developing economies, peer-reviewed research has indicated that, on average, transgenic crops do provide economic advantages for adopting farmers. However, several general caveats are useful to remember when interpreting the findings reported in this initial literature. A number of specific limitations have also been identified in this review. (Smale et al., 2009)

*The **first general caveat** is that only a limited range of transgenic crops has been studied because few have been released in developing countries. Studies of Bt cotton, which has unique economic and agronomic properties, dominate the literature; a few country case studies also dominate the Bt cotton story. Thus we should be careful not to generalize from these experiences to other crop-trait combinations and contexts. Similarly there are relatively few different authors publishing case studies in peer-reviewed international journals, and there is also a wide range of quality among the journals publishing the research.*

*A **second general caveat** is that averages mask considerable variation. The magnitude of the economic advantages varies substantially according to the nature of the cropping season and the geographical location of the study. This would be the case whether or not the seed introduced were transgenic, but the variation is particularly pronounced for IR crops. Variability in crop yields and profitability reflects the reliance of agricultural production on uncertain weather conditions and pest pressures, combined with the heterogeneity of farmers, farming systems, and farm-related institutions. Not all farmers will benefit from IR crops in every cropping season, and this variability is difficult to capture in cross-sectional data collected in single locations.*

*Related **to this caveat is a third**: the length of the period over which adoption and impact are observed can dramatically influence the conclusions drawn by researchers.*

Some success stories are episodic; others are not apparent until years have passed. The impacts we are able to observe also depend on the point along the adoption path that is studied. During the initial years of adoption, it makes sense that researchers have focused on the relative profitability of transgenic crops; if transgenic crops are not advantageous for farmers, they will not adopt them and there will be

no measurable impact of any kind. Only after farmers have planted transgenic crops for a number of years can we assess empirically the effects of adoption on poverty, inequality, health, and the environment." (Smale et al., 2009)

8. Biofortification should also be taken into account when talking about yield

Worldwide, there are dozens of projects working efficiently on bio-fortification, so to say an inner development of crop yield, foremost the well advanced project of the Golden Rice, which will be ready at the latest in the year 2012, and this only due to exaggerated risk assessment regulations and also due to massive opposition of multinational protest corporate organizations. Clearly these are prospects for the near and far future, but considering the fact that all those projects work with novel crops distributed to the poor free of royalties, just as their normal crops, it will be economically and nutritionally of considerable benefit to millions of hungry people.

Al-Babili, S. & Beyer, P. (2005)

Golden Rice - five years on the road - five years to go? Trends in Plant Science, 10, 12, pp 565-573
<Go to ISI>://000234155300005 AND http://www.botanischergarten.ch/Rice/Babili-Golden-Rice-5years-2005.pdf

Through agriculture and local trade, GR is expected to reach the target populations, namely the urban poor and rural populations, particularly those living in remote areas. Here GR is expected to complement more traditional interventions, such as industrial food fortification and supplementation, effectively and sustainably. These interventions rely on centrally processed food items, on the maintenance of adequate distribution logistics and on the specific targeting of deficient populations, and require significant on-going costs to be sustained. GR, in principle, should require little more than the costs of reliable seed production systems for its continued deployment. (Al-Babili & Beyer, 2005)

Mayer, J.E., Pfeiffer, W.H., & Beyer, P. (2008)

Biofortified crops to alleviate micronutrient malnutrition. Genome studies and Molecular Genetics, edited by Juliette de Meaux and Maarten Koornneef / Plant Biotechnology, edited by Andy Greenland and Jan Leach, 11, 2, pp 166-170
http://www.sciencedirect.com/science/article/B6VS4-4S0R701-1/1/e12139b40ae67abc932e4bdb46069503 AND
http://www.botanischergarten.ch/Rice/Mayer-Biofortified-COPB-2008..pdf

Micronutrient malnutrition affects more than half of the world population, particularly in developing countries. Concerted international and national fortification and supplementation efforts to curb the scourge of micronutrient malnutrition are showing a positive impact, alas without reaching the goals set by international organizations. Bio-fortification, the delivery of micronutrients via micronutrient-dense crops, offers a cost-effective and sustainable approach, complementing these efforts by reaching rural populations. Bio-available micronutrients in the edible parts of staple crops at concentrations high enough to impact on human health can be obtained through breeding, provided that sufficient genetic variation for a given trait exists, or through transgenic approaches. Research and breeding programs are underway to enrich the major food staples in developing countries with the most important micronutrients: iron, pro-vitamin A, zinc and folate. (Mayer et al., 2008)

Qaim, M., Stein, A.J., & Meenakshi, J.V. (2007)

Economics of biofortification. Agricultural Economics, 37, pp 119-133
<Go to ISI>://WOS:000251940700010 AND http://www.botanischergarten.ch/Biofuel/Qaim-Economics-Biofortification.pdf

"Micronutrient malnutrition is a serious public health problem in many developing countries. Different interventions are currently used, but their overall coverage is relatively limited. Biofortification-that is, breeding staple food crops for higher micronutrient contents-is a new agriculture-based approach, but relatively little is known about its ramifications. Here, the main factors influencing success are discussed and a methodology for economic impact assessment is presented. Ex ante studies from India and other countries suggest that biofortified crops can reduce the problem of micronutrient malnutrition in a cost-effective

way, when targeted to specific situations. Further research is needed to corroborate these findings and address certain issues still unresolved. " (Qaim et al., 2007)

Bouis, H.E. (2007)
The potential of genetically modified food crops to improve human nutrition in developing countries. Journal of Development *Studies, 43, 1, pp 79-96 AND http://www.botanischergarten.ch/Developing/Bouis-Potential-GM-crops-2007.pdf*

Because of poor dietary quality and consequent widespread micronutrient malnutrition in low income countries, children and their mothers, who have higher requirements for vitamins and minerals due to rapid growth and reproduction respectively, have higher mortality, become sick more often, have their cognitive abilities compromised for a lifetime, and are less productive members of the workforce. Their quality of life and aggregate economic growth are unnecessarily compromised. One way that biotechnology can help to improve the nutrition and health of consumers in developing countries is by increasing the vitamin and mineral content and their bioavailability in staple foods. (Bouis, 2007).

Pfeiffer, W.H. & McClafferty, B. (2007)
HarvestPlus: Breeding crops for better nutrition. Crop Science, 47, pp S88-S105 *AND*
http://www.botanischergarten.ch/Biofortification/Pfeiffer-HarvestPlus-Nutrition-2007.pdf

"Micronutrient malnutrition, the so-called hidden hunger, affects more than one-half of the world's population, especially women and preschool children in developing countries. Despite past progress in controlling micronutrient decencies through supplementation and food fortification, new approaches are needed to expand the reach of food-based interventions. Bio-fortification, a new approach that relies on conventional plant breeding and modern biotechnology to increase the micronutrient density of staple crops, holds great promise for improving the nutritional status and health of poor populations in both rural and urban areas of the developing world. HarvestPlus, a research program implemented with the international research institutes of the CGIAR, targets a multitude of crops that are a regular part of the staple-based diets of the poor and breeds them to be rich in iron, zinc, and pro-vitamin A. This paper emphasizes the need for interdisciplinary research and addresses the key research issues and methodological considerations for success. The major activities to be undertaken are broadly grouped into research related to nutrition research and impact analysis, and research considerations for delivering biofortifi ed crops to end-users effectively. The paper places particular emphasis on the activities of the plant breeding and genetics component of this multidisciplinary program. The authors argue that for bio-fortification to succeed, product profi les developed by plant breeders must be driven by nutrition research and impact objectives and that nutrition research must understand that the probability of success for bio-fortified crops increases substantially when product concepts consider farmer adoption and, hence, agronomic superiority." (Pfeiffer & McClafferty, 2007)

Zimmermann, R. & Qaim, M. (2004)
Potential health benefits of Golden Rice: a Philippine case study. Food Policy, 29, 2, pp 147-168 and
http://www.botanischergarten.ch/Rice/Zimmermann-Benefit-Goldenrice.pdf

Golden Rice has been genetically modified to produce beta-carotene in the endosperm of grain. It could improve the vitamin A status of deficient food consumers, especially women and children in developing countries. This paper analyses potential impacts in a Philippine context. Since the technology is still at the stage of R&D, benefits are simulated with a scenario approach. Health effects are quantified using the methodology of disability-adjusted life years (DALYs). Golden Rice will not completely eliminate the problems of vitamin A deficiency, such as blindness or increased mortality. Therefore, it should be seen as a complement rather than a substitute for alternative micronutrient interventions. Yet the technology could bring about significant benefits. Depending on the underlying assumptions, annual health improvements are worth between US$ 16 and 88 million, and rates of return on R&D investments range between 66% and 133%. Due to the uncertainty related to key parameters, these results should be treated as preliminary. (Zimmermann & Qaim, 2004).

9. Cotton yield data have increased, the example of India

Cotton in India has not been the subject of the study of UCN of (Gurian-Sherman, 2009), this is a case of clear yield increase one should mention here in this context.

Qaim, M. & Zilberman, D. (2003)
Yield effects of genetically modified crops in developing countries. Science, 299, 5608, pp 900-902
<Go to ISI>://000180830900055 AND http://www.botanischergarten.ch/Cotton/Quaim-Zilberman-Bt-Cotton-2003.pdf

On-farm field trials carried out with Bacillus thuringiensis (Bt) cotton in different states of India show that the technology substantially reduces pest damage and increases yields. The yield gains are much higher than what has been reported for other countries where genetically modified crops were used mostly to replace and enhance chemical pest control. In many developing countries, small-scale farmers especially suffer big pest-related yield losses because of technical and economic constraints. Pest-resistant genetically modified crops can contribute to increased yields and agricultural growth in those situations, as the case of Bt cotton in India demonstrates." (Qaim & Zilberman, 2003)

The fact of Indian farmers suicides is a sad tradition, which started way before the introduction of GM cotton, and the mounting yields and reduced highly toxic pesticide use is on the contrary very helpful and increases the quality of the livelihood of the poor farmers, see the balanced analysis of this issue: (Gruere Guillaume P. et al., 2008).

10. Earlier controversy on benefits of transgenic corn

(Obrycki et al., 2001), claimed in their analysis of transgenic insecticidal corn developed for lepidopteran pests that the potential benefits of crop genetic engineering for insect pest management may not outweight the potential ecological and economic risks. Together with a large consortium of specialists (Ortman et al., 2001) answered in the same journal, the main claim again: for answering such questions you absolutely need to obey to baseline comparisons.

"Positive and negative impacts of new technologies must be compared with those of existing technologies. All possible impacts of any technology or farming practice are impossible to foresee, but we can focus on known and probable risks. When risks of a technology are characterized as low, based on actual data, then the potential impact should be evaluated proportional to that level of concern. This reasonable approach should reduce the chances of rejecting safe technologies simply because they are new and unfamiliar. Ultimately, the goal is to replace current pest management practices with ones that are more economical and sustainable, as well as environmentally safer. A dynamic equilibrium between benefits and risks will be developed as a result of this ongoing process.Over time, this equilibrium will change as improved practices are developed. In the meantime, if unexpected problems should occur, failsafe mechanisms exist. Any pesticidal technology registered by the EPA can have its registration suspended or canceled when an unreasonable adverse effect is identified. The scientific community has examined the risks and benefits of Bt plants more than any other novel agricultural technology developed over the past two decades, as demonstrated by the vast body of literature, scientific discussions, and numerous public meetings facilitated by the EPA, the US Department of Agriculture, and the US Food and Drug Administration on this subject.We find the evidence to date supports the appropriate use of Bt corn as one component in the economically and ecologically sound management of lepidopteran corn pests." (Ortman et al., 2001).

This is just another example, that the UCS study (Gurian-Sherman, 2009) did not build on a thorough literature search, since it is not referring to the dispute.

11. Two Recently published papers in Nature Biotechnology:

11.1. Contradiction to Gurian-Sherman by Sheridan 2009

In a critical account, Nature Biotechnology produced a feature on the report of (Gurian-Sherman, 2009):

Sheridan, C. (2009)
Report claims no yield advantage for Bt crops. Nat Biotech, 27, 7, pp 588-589
http://dx.doi.org/10.1038/nbt0709-588 AND http://www.botanischergarten.ch/Yield/Sheridan-UCS-Crop-Failure-NB-2009.pdf

Excerpt from the experts comments:
"Not all public-sector crop scientists contacted by Nature Biotechnology responded to interview requests, ***but those who did were uniformly critical of the report****. "What I object to most about the spin is you've got a false antithesis set up—genetically engineered traits versus breeding. We need both/and, not either/or," says Jonathan Jones, head of the Sainsbury Laboratory at the John Innes Centre in Norwich, UK, and a cofounder of plant biotech firm Mendel Biotechnology, of Hayward, California. He also rejects the view that public sector agriculture research is overly focused on biotech. "If it's true at all, it's not true in Europe. It's a rather parochial view." And he holds anti-GE campaigners responsible for the cost of regulating transgenic crops, which makes it impossible for public-sector organizations to bring their own innovations to the market. "It strengthens the monopoly position of Monsanto et. al. That is an ironic own-goal of the anti-GE campaigners," he says.*

Ken Ostlie, a professor in the Department of Entomology at the University of Minnesota in St. Paul, the Bt toxin genes introduced to corn hybrids are actually benefitting conventional and organic growers indirectly. "These traits are highly effective against the corn borer, and widespread use of Bt corn has actually collapsed the corn borer population," he says. "Everybody's benefitting from that, but you don't see it looking at operational yield benefits at the current time."

"It's the wrong question; it's the wrong analysis; it's the wrong everything," says Wayne Parrott, of the University of Georgia in Athens. "You've got to get past the experimental field trials and look at what's happening on the farm itself." Field trials, he says, are "designed to see what the crop will do under optimal conditions—that's seldom what you'll find on a farm." (Sheridan, 2009)

This is just another example, that the UCS study (Gurian-Sherman, 2009) did not build on a thorough literature search.

11.2. New large scale survey based on farmers experience with GM crops

In another paper a survey of peer reviewed publications are summarized by (Carpenter, 2010), the main conclusions:
A large scale analysis of farmers experience with GM crops concludes that biotech crops have a positive impact on economic performance and yields for farmers around the world, especially those in developing countries

Methodology:
An analysis of 49 peer-reviewed publications reporting on farmer surveys that compare yields and other indicators of economic performance of GM and non-GM crops
The main GM traits evaluated are insect-resistance and herbicide-tolerance

- **Yield comparison:**
  74% of yield comparisons of biotech and conventional crops showed positive results for adopters of biotech crops versus non-adopters
  When looking to developing countries alone, this number mounts up to 82 percent
  The average increases for developing countries range from 16 percent for insect-resistant corn to 30 percent for insect-resistant cotton.

- **Economic performance:**
  72 %t of the results are positive when GM crops are compared with their conventional counterparts
  For herbicide-tolerant crops, 71% show a positive impact on economic performance
  For insect-resistant crops, 74% show a positive impact on economic performance

- **Influence of GMOs on the environment:**
  Biotech crops help preserve the environment by facilitating conservation tillage and reducing the number of applications of insecticides

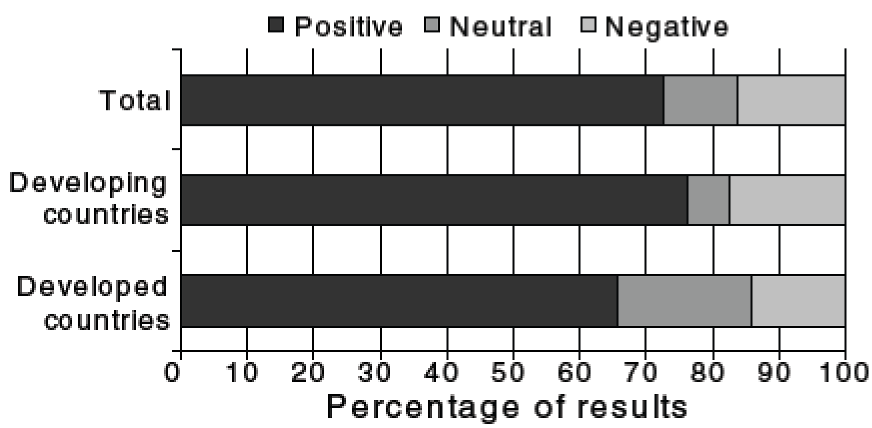

Fig. 2 Results by direction of change in economic performance (GM – conventional). A χ2 test shows a significant difference in the proportion of positive results for developed and developing countries (χ2 = 0.68, df = 1, *P* = 0.41).

12. Helpful new blog

can be easily identified via google, under Union of Concerned Scientists, and as usual, with enthusiastic approval of the new report, but without any scientific scrutiny. There are a few critical ones, such as:

Karl Haro von Mogels new blog “Bio-fortified” offers good arguments and links to other blogs
http://www.biofortified.org/2009/04/union-of-concerned-scientists-ge-crops-have-not-decreased-yields/

13. Report of the National Research Committee 2010

In a summary, the report reflects the broad range of experts invited to compile an opinion on the topic of Impact of Genetically Engineered Crops on Farm Sustainability in the United States (National Research Council, 2010).

"With the advent of genetic-engineering technology in agriculture, the science of crop improvement has evolved into a new realm. Advances in molecular and cellular biology now allow scientists to introduce desirable traits from other species into crop plants. The ability to transfer genes between species is a leap beyond crop improvement through previous plantbreeding techniques, whereby desired traits could be transferred only between related types of plants. The most commonly introduced genetically engineered (GE) traits allow plants either to produce their own insecticide, so that the yield lost to insect feeding is reduced, or to resist herbicides, so that herbicides can be used to kill a broad spectrum of weeds without harming crops. Those traits have been incorporated into most varieties of soybean, corn, and cotton grown in the United States.

Since their introduction in 1996, the use of (GE crops in the United States has grown rapidly and accounted for over 80 percent of soybean, corn, and cotton acreage in the United States in 2009. Several National Research Council reports have addressed the effects of GE crops on the environment and on human health.1 However, the effects of agricultural biotechnology at the farm level-that is, from the point of view of the farmer-have received much less attention. To fill that information gap, the National Research Council initiated a study, supported by its own funds, of how GE crops have affected U.S. farmers-their incomes, agronomic practices, production decisions, environmental resources, and personal well-being. This report of the study's findings expands the perspectives from which genetic-engineering technology has been examined previously. It provides the first comprehensive assessment of the effects of GE-crop adoption on farm sustainability in the United States (Box S-1)."

A few figures show clearly the benefits and positive developments of GM crops in the United States and elsewhere:

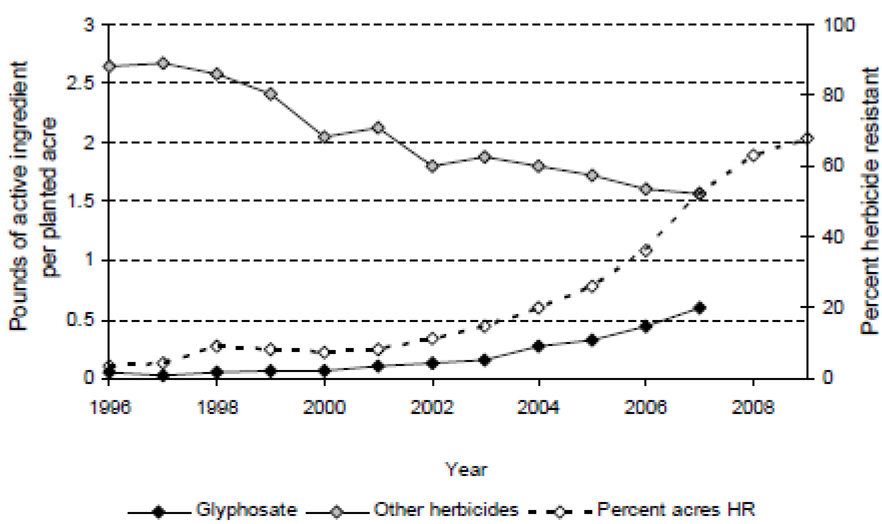

Fig. 3 Application of herbicide to corn and percentage of HR corn. NOTE: The strong correlation between the rising percentage of herbicide-resistant (HR) corn acres planted over time, the increased applications of glyphosate, and the decreased use of other herbicides suggests but does not confirm causation between these variables. SOURCES: USDA-NASS, 2001; 2003, 2005, 2007, 2009a, b; citations see report, and (Fernandez-Cornejo & Caswell, 2006).

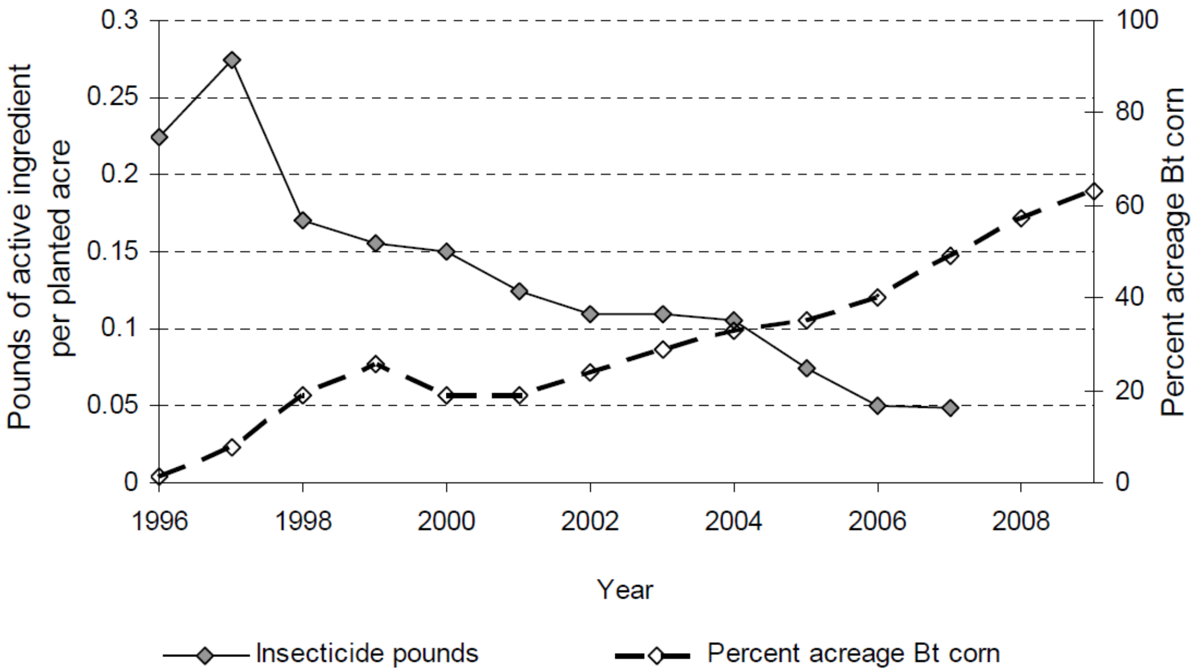

Fig. 4 Pounds of insecticide applied per planted acre and percent acres of Bt corn, respectively. NOTE: The strong correlation between the rising percentage of Bt corn acres planted over time and the decrease in insecticide pounds per planted acre suggests but does not confirm causation between these variables. SOURCES: USDA-NASS, 2001; 2003, 2005, 2007, 2009a, b; (see report) and (Fernandez-Cornejo & Caswell, 2006).

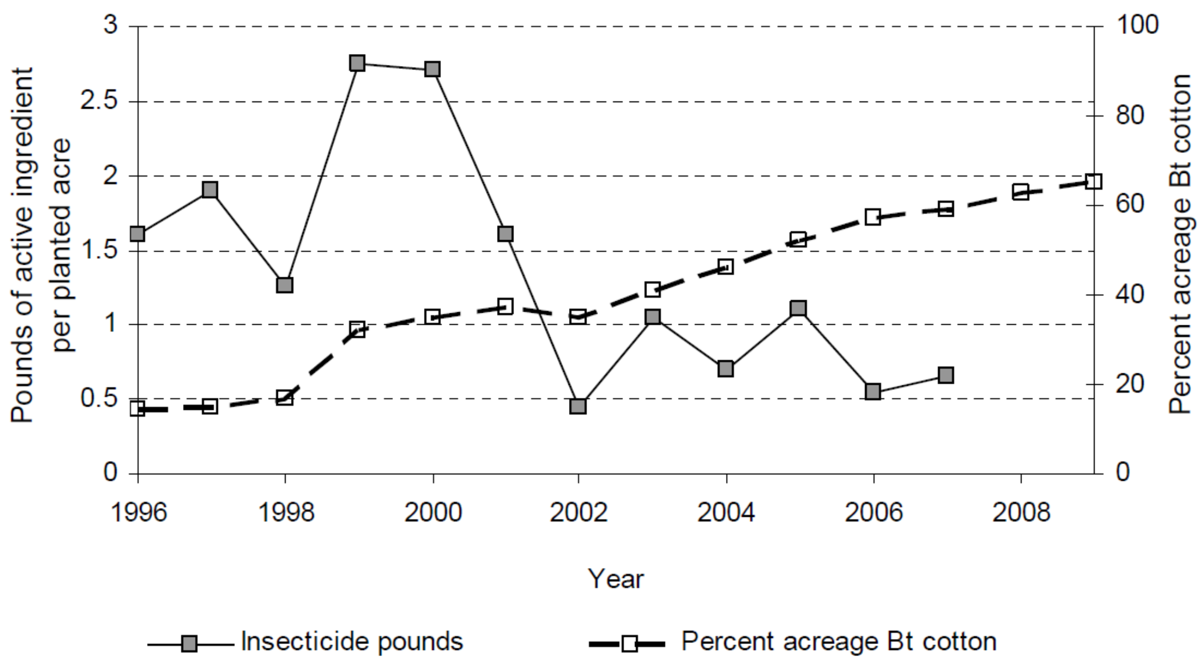

Fig. 5 Pounds of insecticide applied per planted acre and percent acres of Bt cotton, respectively. NOTE: The strong correlation between the rising percentage of Bt cotton acres planted over time and the decrease in insecticide pounds per

planted acre suggests but does not confirm causation between these variables. SOURCES: USDA-NASS, 2001; 2003, 2005, 2007, 2009a, b; (see report) and (Fernandez-Cornejo & Caswell, 2006).

The conclusion No. 4 of the report:

*"**Conclusion 4**. Commercialized GE traits are targeted at pest control, and when used properly, they have been effective at reducing pest problems with economic and environmental benefits to farmers. However, genetic engineering could be used in more crops, in novel ways beyond herbicide and insecticide resistance, and for a greater diversity of purposes. With proper management, genetic-engineering technology could help address food insecurity by reducing yield losses through its introduction into other crops and with the development of other yield protection traits like drought tolerance. Crop biotechnology could also address "public goods" issues that will be undersupplied by the market acting alone. Some firms are working on GE traits that address public goods issues. However, industry has insufficient incentive to invest enough in research and development for those purposes when firms cannot collect revenue from innovations that generate net benefits beyond the farm. Therefore, the development of these traits will require greater collaboration between the public and private sectors because the benefits extend beyond farmers to the society in general. The implementation of a targeted and tailored regulatory approach to GE-trait development and commercialization that meets human and environmental safety standards while minimizing unnecessary expenses will aid this agenda (Ervin & Welsh, 2006).*

The report is commented by an independent author from a Californian University: the full text can also serve as a final comment for the piece on yield and performance of GM crops:

Genetically Engineered Distortions By PAMELA C. RONALD and JAMES E. McWILLIAMS Published: May 14, 2010 [1]

A REPORT by the National Research Council last month gave ammunition to both sides in the debate over the cultivation of genetically engineered crops. More than 80 percent of the corn, soybeans and cotton grown in the United States is genetically engineered, and the report details the "long and impressive list of benefits" that has come from these crops, including improved soil quality, reduced erosion and reduced insecticide use.
It also confirmed predictions that widespread cultivation of these crops would lead to the emergence of weeds resistant to a commonly used herbicide, glyphosate (marketed by Monsanto as Roundup). Predictably, both sides have done what they do best when it comes to genetically engineered crops: they've argued over the findings.

Lost in the din is the potential role this technology could play in the poorest regions of the world — areas that will bear the brunt of climate change and the difficult growing conditions it will bring. Indeed, buried deep in the council's report is an appeal to apply genetic engineering to a greater number of crops, and for a greater diversity of purposes.

Appreciating this potential means recognizing that genetic engineering can be used not just to modify major commodity crops in the West, but also to improve a much wider range of crops that can be grown in difficult conditions throughout the world.

Doing that also requires opponents to realize that by demonizing the technology, they've hindered applications of genetic engineering that could save lives and protect the environment.

Scientists at nonprofit institutions have been working for more than two decades to genetically engineer seeds that could benefit farmers struggling with ever-pervasive dry spells and old and novel pests. Drought-tolerant cassava, insect-resistant cowpeas, fungus-resistant bananas, virus-resistant sweet potatoes and high-yielding pearl millet are just a few examples of genetically engineered foods that could improve the lives of the poor around the globe.

For example, researchers in the public domain have been working to engineer sorghum crops that are resistant to both drought and an aggressively parasitic African weed, Striga.

[1] Pamela C. Ronald and James E. McWilliams, New York Times May 14, 2010:
http://www.botanischergarten.ch/Benefits/Ronald-GM-Distortions-NY-Times-201005.PDF

In a 1994 pilot project by the United States Agency for International Development, an experimental variety of engineered sorghum had a yield four times that of local varieties under adverse conditions. Sorghum, a native of the continent, is a staple throughout Africa, and improved sorghum seeds would be widely beneficial.

As well as enhancing yields, engineered seeds can make crops more nutritious. A new variety of rice modified to produce high amounts of provitamin A, named Golden Rice, will soon be available in the Philippines and, if marketed, would almost assuredly save the lives of thousands of children suffering from vitamin A deficiency.

There's also a sorghum breed that's been genetically engineered to produce micronutrients like zinc, and a potato designed to contain greater amounts of protein.

To appreciate the value of genetic engineering, one need only examine the story of papaya. In the early 1990s, Hawaii's papaya industry was facing disaster because of the deadly papaya ringspot virus. Its single-handed savior was a breed engineered to be resistant to the virus. Without it, the state's papaya industry would have collapsed. Today, 80 percent of Hawaiian papaya is genetically engineered, and there is still no conventional or organic method to control ringspot virus.

The real significance of the papaya recovery is not that genetic engineering was the most appropriate technology delivered at the right time, but rather that the resistant papaya was introduced before the backlash against engineered crops intensified.

Opponents of genetically engineered crops have spent much of the last decade stoking consumer distrust of this precise and safe technology, even though, as the research council's previous reports noted, engineered crops have harmed neither human health nor the environment.

In doing so, they have pushed up regulatory costs to the point where the technology is beyond the economic reach of small companies or foundations that might otherwise develop a wider range of healthier crops for the neediest farmers. European restrictions, for instance, make it virtually impossible for scientists at small laboratories there to carry out field tests of engineered seeds.

As it now stands, opposition to genetic engineering has driven the technology further into the hands of a few seed companies that can afford it, further encouraging their monopolistic tendencies while leaving it out of reach for those that want to use it for crops with low (or no) profit margins.

The stakes are too high for us not to make the best use of genetic engineering. If we fail to invest responsibly in agricultural research, if we continue to allow propaganda to trump science, then the potential for global agriculture to be productive, diverse and sustainable will go unfulfilled. And it's not those of us here in the developed world who will suffer the direct consequences, but rather the poorest and most vulnerable.

Pamela C. Ronald, a professor of plant pathology at the University of California, Davis, is the co-author of "Tomorrow's Table: Organic Farming, Genetics and the Future of Food." James E. McWilliams, a history professor at Texas State University at San Marcos, is the author of "Just Food."

14. Links to a collection of useful slides related to yield and development of crops

In order to help convey this message, here below a collection of slides, partially shown in the above.

http://www.botanischergarten.ch/Yield/Yield-Related-1.ppt

http://www.botanischergarten.ch/Yield/Yield-Related-1.pdf

Two selected slides show the contrast between progressive United States agriculture with a decisive hike in yield of corn (a bit less for soybean), and the not so positive situation in Europe, the result of farmers and resisting persistently to new agricultural technologies:

http://www.botanischergarten.ch/Yield/Yield-Comparison-Corn-USA-Europe.pdf
http://www.botanischergarten.ch/Yield/Yield-Comparison-Corn-USA-Europe.ppt

From (Carpenter, 2010)
http://www.botanischergarten.ch/Benefits/Carpenter-Peer-Reviewed-Surveys-2010.ppt

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